US009750442B2

(12) **United States Patent**
Olsen

(10) **Patent No.: US 9,750,442 B2**
(45) **Date of Patent: Sep. 5, 2017**

(54) **PHYSIOLOGICAL STATUS MONITOR**

(71) Applicant: **Masimo Corporation**, Irvine, CA (US)

(72) Inventor: **Gregory A. Olsen**, Trabuco Canyon, CA (US)

(73) Assignee: **Masimo Corporation**, Irvine, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 50 days.

(21) Appl. No.: **14/203,524**

(22) Filed: **Mar. 10, 2014**

(65) **Prior Publication Data**

US 2015/0051462 A1 Feb. 19, 2015

Related U.S. Application Data

(60) Provisional application No. 61/775,568, filed on Mar. 9, 2013.

(51) **Int. Cl.**
A61B 5/145 (2006.01)
A61B 5/00 (2006.01)

(52) **U.S. Cl.**
CPC ***A61B 5/14542*** (2013.01); ***A61B 5/743*** (2013.01); *A61B 5/7275* (2013.01); *A61B 5/746* (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,960,128 A 10/1990 Gordon et al.
4,964,408 A 10/1990 Hink et al.
5,041,187 A 8/1991 Hink et al.
5,069,213 A 12/1991 Polczynski
5,163,438 A 11/1992 Gordon et al.
5,319,355 A 6/1994 Russek
5,337,744 A 8/1994 Branigan
5,341,805 A 8/1994 Stavridi et al.
D353,195 S 12/1994 Savage et al.
D353,196 S 12/1994 Savage et al.
5,377,676 A 1/1995 Vari et al.
D359,546 S 6/1995 Savage et al.
5,431,170 A 7/1995 Mathews
D361,840 S 8/1995 Savage et al.
D362,063 S 9/1995 Savage et al.
5,452,717 A 9/1995 Branigan et al.
D363,120 S 10/1995 Savage et al.
5,456,252 A 10/1995 Vari et al.
5,479,934 A 1/1996 Imran
(Continued)

OTHER PUBLICATIONS

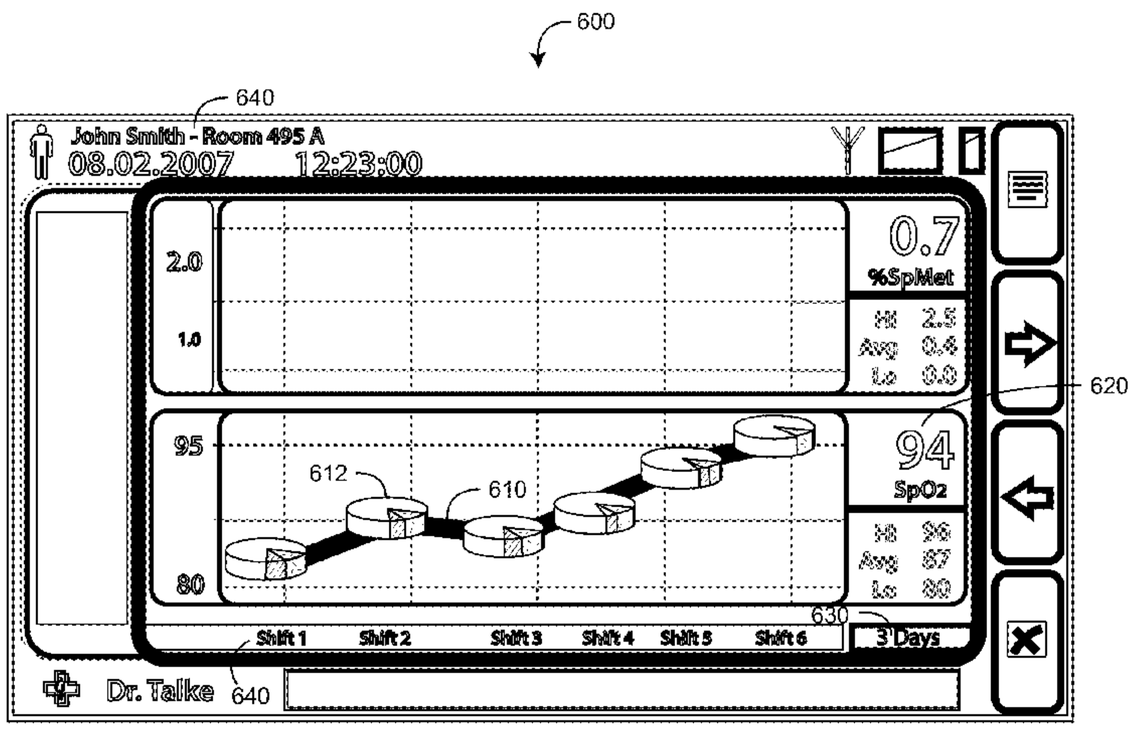
US 8,845,543, 09/2014, Diab et al. (withdrawn)
(Continued)

Primary Examiner — Kumar Patel
Assistant Examiner — Richard M Russell
(74) *Attorney, Agent, or Firm* — Knobbe Martens Olson & Bear, LLP

(57) **ABSTRACT**

A physiological status monitor has a monitor and an interconnected sensor that generates a sensor signal. The monitor computes physiological parameters responsive to the sensor signal and displays physiological parameters accordingly. In an embodiment, the monitor displays physiological parameter information across multiple patients in a cumulative pie chart format so that a caregiver can quickly discern and readily identify patients in need of immediate medical attention.

3 Claims, 8 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

5,482,036	A	1/1996	Diab et al.
5,490,505	A	2/1996	Diab et al.
5,494,043	A	2/1996	O'Sullivan et al.
5,533,511	A	7/1996	Kaspari et al.
5,534,851	A	7/1996	Russek
5,561,275	A	10/1996	Savage et al.
5,562,002	A	10/1996	Lalin
5,590,649	A	1/1997	Caro et al.
5,602,924	A	2/1997	Durand et al.
5,632,272	A	5/1997	Diab et al.
5,638,816	A	6/1997	Kiani-Azarbayjany et al.
5,638,818	A	6/1997	Diab et al.
5,645,440	A	7/1997	Tobler et al.
5,685,299	A	11/1997	Diab et al.
D393,830	S	4/1998	Tobler et al.
5,743,262	A	4/1998	Lepper, Jr. et al.
5,758,644	A	6/1998	Diab et al.
5,760,910	A	6/1998	Lepper, Jr. et al.
5,769,785	A	6/1998	Diab et al.
5,782,757	A	7/1998	Diab et al.
5,785,659	A	7/1998	Caro et al.
5,791,347	A	8/1998	Flaherty et al.
5,810,734	A	9/1998	Caro et al.
5,823,950	A	10/1998	Diab et al.
5,830,131	A	11/1998	Caro et al.
5,833,618	A	11/1998	Caro et al.
5,860,919	A	1/1999	Kiani-Azarbayjany et al.
5,890,929	A	4/1999	Mills et al.
5,904,654	A	5/1999	Wohltmann et al.
5,919,134	A	7/1999	Diab
5,934,925	A	8/1999	Tobler et al.
5,940,182	A	8/1999	Lepper, Jr. et al.
5,995,855	A	11/1999	Kiani et al.
5,997,343	A	12/1999	Mills et al.
6,002,952	A	12/1999	Diab et al.
6,011,986	A	1/2000	Diab et al.
6,027,452	A	2/2000	Flaherty et al.
6,036,642	A	3/2000	Diab et al.
6,045,509	A	4/2000	Caro et al.
6,067,462	A	5/2000	Diab et al.
6,081,735	A	6/2000	Diab et al.
6,088,607	A	7/2000	Diab et al.
6,110,522	A	8/2000	Lepper, Jr. et al.
6,124,597	A	9/2000	Shehada
6,128,521	A	10/2000	Marro et al.
6,129,675	A	10/2000	Jay
6,144,868	A	11/2000	Parker
6,151,516	A	11/2000	Kiani-Azarbayjany et al.
6,152,754	A	11/2000	Gerhardt et al.
6,157,850	A	12/2000	Diab et al.
6,165,005	A	12/2000	Mills et al.
6,184,521	B1	2/2001	Coffin, IV et al.
6,206,830	B1	3/2001	Diab et al.
6,229,856	B1	5/2001	Diab et al.
6,232,609	B1	5/2001	Snyder et al.
6,236,872	B1	5/2001	Diab et al.
6,241,683	B1	6/2001	Macklem et al.
6,253,097	B1	6/2001	Aronow et al.
6,256,523	B1	7/2001	Diab et al.
6,263,222	B1	7/2001	Diab et al.
6,278,522	B1	8/2001	Lepper, Jr. et al.
6,280,213	B1	8/2001	Tobler et al.
6,285,896	B1	9/2001	Tobler et al.
6,301,493	B1	10/2001	Marro et al.
6,317,627	B1	11/2001	Ennen et al.
6,321,100	B1	11/2001	Parker
6,325,761	B1	12/2001	Jay
6,334,065	B1	12/2001	Al-Ali et al.
6,343,224	B1	1/2002	Parker
6,349,228	B1	2/2002	Kiani et al.
6,360,114	B1	3/2002	Diab et al.
6,368,283	B1	4/2002	Xu et al.
6,371,921	B1	4/2002	Caro et al.
6,377,829	B1	4/2002	Al-Ali
6,388,240	B2	5/2002	Schulz et al.
6,397,091	B2	5/2002	Diab et al.
6,430,437	B1	8/2002	Marro
6,430,525	B1	8/2002	Weber et al.
6,463,311	B1	10/2002	Diab
6,470,199	B1	10/2002	Kopotic et al.
6,501,975	B2	12/2002	Diab et al.
6,505,059	B1	1/2003	Kollias et al.
6,515,273	B2	2/2003	Al-Ali
6,519,487	B1	2/2003	Parker
6,525,386	B1	2/2003	Mills et al.
6,526,300	B1	2/2003	Kiani et al.
6,541,756	B2	4/2003	Schulz et al.
6,542,764	B1	4/2003	Al-Ali et al.
6,580,086	B1	6/2003	Schulz et al.
6,584,336	B1	6/2003	Ali et al.
6,595,316	B2	7/2003	Cybulski et al.
6,597,932	B2	7/2003	Tian et al.
6,597,933	B2	7/2003	Kiani et al.
6,606,511	B1	8/2003	Ali et al.
6,632,181	B2	10/2003	Flaherty et al.
6,639,668	B1	10/2003	Trepagnier
6,640,116	B2	10/2003	Diab
6,643,530	B2	11/2003	Diab et al.
6,650,917	B2	11/2003	Diab et al.
6,654,624	B2	11/2003	Diab et al.
6,658,276	B2	12/2003	Kiani et al.
6,661,161	B1	12/2003	Lanzo et al.
6,671,531	B2	12/2003	Al-Ali et al.
6,678,543	B2	1/2004	Diab et al.
6,684,090	B2	1/2004	Ali et al.
6,684,091	B2	1/2004	Parker
6,697,656	B1	2/2004	Al-Ali
6,697,657	B1	2/2004	Shehada et al.
6,697,658	B2	2/2004	Al-Ali
RE38,476	E	3/2004	Diab et al.
6,699,194	B1	3/2004	Diab et al.
6,714,804	B2	3/2004	Al-Ali et al.
RE38,492	E	4/2004	Diab et al.
6,721,582	B2	4/2004	Trepagnier et al.
6,721,585	B1	4/2004	Parker
6,725,075	B2	4/2004	Al-Ali
6,728,560	B2	4/2004	Kollias et al.
6,735,459	B2	5/2004	Parker
6,745,060	B2	6/2004	Diab et al.
6,760,607	B2	7/2004	Al-Ali
6,770,028	B1	8/2004	Ali et al.
6,771,994	B2	8/2004	Kiani et al.
6,792,300	B1	9/2004	Diab et al.
6,813,511	B2	11/2004	Diab et al.
6,816,741	B2	11/2004	Diab
6,822,564	B2	11/2004	Al-Ali
6,826,419	B2	11/2004	Diab et al.
6,830,711	B2	12/2004	Mills et al.
6,850,787	B2	2/2005	Weber et al.
6,850,788	B2	2/2005	Al-Ali
6,852,083	B2	2/2005	Caro et al.
6,861,639	B2	3/2005	Al-Ali
6,898,452	B2	5/2005	Al-Ali et al.
6,920,345	B2	7/2005	Al-Ali et al.
6,931,268	B1	8/2005	Kiani-Azarbayjany et al.
6,934,570	B2	8/2005	Kiani et al.
6,939,305	B2	9/2005	Flaherty et al.
6,943,348	B1	9/2005	Coffin, IV
6,950,687	B2	9/2005	Al-Ali
6,961,598	B2	11/2005	Diab
6,970,792	B1	11/2005	Diab
6,979,812	B2	12/2005	Al-Ali
6,985,764	B2	1/2006	Mason et al.
6,993,371	B2	1/2006	Kiani et al.
6,996,427	B2	2/2006	Ali et al.
6,999,904	B2	2/2006	Weber et al.
7,003,338	B2	2/2006	Weber et al.
7,003,339	B2	2/2006	Diab et al.
7,015,451	B2	3/2006	Dalke et al.
7,024,233	B2	4/2006	Ali et al.
7,027,849	B2	4/2006	Al-Ali
7,030,749	B2	4/2006	Al-Ali
7,039,449	B2	5/2006	Al-Ali
7,041,060	B2	5/2006	Flaherty et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,044,918	B2	5/2006	Diab
7,067,893	B2	6/2006	Mills et al.
7,096,052	B2	8/2006	Mason et al.
7,096,054	B2	8/2006	Abdul-Hafiz et al.
7,132,641	B2	11/2006	Schulz et al.
7,142,901	B2	11/2006	Kiani et al.
7,149,561	B2	12/2006	Diab
7,186,966	B2	3/2007	Al-Ali
7,190,261	B2	3/2007	Al-Ali
7,215,984	B2	5/2007	Diab
7,215,986	B2	5/2007	Diab
7,221,971	B2	5/2007	Diab
7,225,006	B2	5/2007	Al-Ali et al.
7,225,007	B2	5/2007	Al-Ali
RE39,672	E	6/2007	Shehada et al.
7,239,905	B2	7/2007	Kiani-Azarbayjany et al.
7,245,953	B1	7/2007	Parker
7,254,429	B2	8/2007	Schurman et al.
7,254,431	B2	8/2007	Al-Ali
7,254,433	B2	8/2007	Diab et al.
7,254,434	B2	8/2007	Schulz et al.
7,272,425	B2	9/2007	Al-Ali
7,274,955	B2	9/2007	Kiani et al.
D554,263	S	10/2007	Al-Ali
7,280,858	B2	10/2007	Al-Ali et al.
7,289,835	B2	10/2007	Mansfield et al.
7,292,883	B2	11/2007	De Felice et al.
7,295,866	B2	11/2007	Al-Ali
7,328,053	B1	2/2008	Diab et al.
7,332,784	B2	2/2008	Mills et al.
7,340,287	B2	3/2008	Mason et al.
7,341,559	B2	3/2008	Schulz et al.
7,343,186	B2	3/2008	Lamego et al.
D566,282	S	4/2008	Al-Ali et al.
7,355,512	B1	4/2008	Al-Ali
7,356,365	B2	4/2008	Schurman
7,371,981	B2	5/2008	Abdul-Hafiz
7,373,193	B2	5/2008	Al-Ali et al.
7,373,194	B2	5/2008	Weber et al.
7,376,453	B1	5/2008	Diab et al.
7,377,794	B2	5/2008	Al-Ali et al.
7,377,899	B2	5/2008	Weber et al.
7,383,070	B2	6/2008	Diab et al.
7,415,297	B2	8/2008	Al-Ali et al.
7,428,432	B2	9/2008	Ali et al.
7,438,683	B2	10/2008	Al-Ali et al.
7,440,787	B2	10/2008	Diab
7,454,240	B2	11/2008	Diab et al.
7,467,002	B2	12/2008	Weber et al.
7,469,157	B2	12/2008	Diab et al.
7,471,969	B2	12/2008	Diab et al.
7,471,971	B2	12/2008	Diab et al.
7,483,729	B2	1/2009	Al-Ali et al.
7,483,730	B2	1/2009	Diab et al.
7,489,958	B2	2/2009	Diab et al.
7,496,391	B2	2/2009	Diab et al.
7,496,393	B2	2/2009	Diab et al.
D587,657	S	3/2009	Al-Ali et al.
7,499,741	B2	3/2009	Diab et al.
7,499,835	B2	3/2009	Weber et al.
7,500,950	B2	3/2009	Al-Ali et al.
7,509,154	B2	3/2009	Diab et al.
7,509,494	B2	3/2009	Al-Ali
7,510,849	B2	3/2009	Schurman et al.
7,526,328	B2	4/2009	Diab et al.
7,530,942	B1	5/2009	Diab
7,530,949	B2	5/2009	Al Ali et al.
7,530,955	B2	5/2009	Diab et al.
7,563,110	B2	7/2009	Al-Ali et al.
7,596,398	B2	9/2009	Al-Ali et al.
7,618,375	B2	11/2009	Flaherty
D606,659	S	12/2009	Kiani et al.
7,647,083	B2	1/2010	Al-Ali et al.
D609,193	S	2/2010	Al-Ali et al.
D614,305	S	4/2010	Al-Ali et al.
RE41,317	E	5/2010	Parker
7,729,733	B2	6/2010	Al-Ali et al.
7,734,320	B2	6/2010	Al-Ali
7,761,127	B2	7/2010	Al-Ali et al.
7,761,128	B2	7/2010	Al-Ali et al.
7,764,982	B2	7/2010	Dalke et al.
D621,516	S	8/2010	Kiani et al.
7,791,155	B2	9/2010	Diab
7,801,581	B2	9/2010	Diab
7,822,452	B2	10/2010	Schurman et al.
RE41,912	E	11/2010	Parker
7,844,313	B2	11/2010	Kiani et al.
7,844,314	B2	11/2010	Al-Ali
7,844,315	B2	11/2010	Al-Ali
7,865,222	B2	1/2011	Weber et al.
7,873,497	B2	1/2011	Weber et al.
7,880,606	B2	2/2011	Al-Ali
7,880,626	B2	2/2011	Al-Ali et al.
7,891,355	B2	2/2011	Al-Ali et al.
7,894,868	B2	2/2011	Al-Ali et al.
7,899,507	B2	3/2011	Al-Ali et al.
7,899,518	B2	3/2011	Trepagnier et al.
7,904,132	B2	3/2011	Weber et al.
7,909,772	B2	3/2011	Popov et al.
7,910,875	B2	3/2011	Al-Ali
7,919,713	B2	4/2011	Al-Ali et al.
7,937,128	B2	5/2011	Al-Ali
7,937,129	B2	5/2011	Mason et al.
7,937,130	B2	5/2011	Diab et al.
7,941,199	B2	5/2011	Kiani
7,951,086	B2	5/2011	Flaherty et al.
7,957,780	B2	6/2011	Lamego et al.
7,962,188	B2	6/2011	Kiani et al.
7,962,190	B1	6/2011	Diab et al.
7,976,472	B2	7/2011	Kiani
7,988,637	B2	8/2011	Diab
7,990,382	B2	8/2011	Kiani
7,991,446	B2	8/2011	Ali et al.
8,000,761	B2	8/2011	Al-Ali
8,008,088	B2	8/2011	Bellott et al.
RE42,753	E	9/2011	Kiani-Azarbayjany et al.
8,019,400	B2	9/2011	Diab et al.
8,028,701	B2	10/2011	Al-Ali et al.
8,029,765	B2	10/2011	Bellott et al.
8,036,727	B2	10/2011	Schurman et al.
8,036,728	B2	10/2011	Diab et al.
8,046,040	B2	10/2011	Ali et al.
8,046,041	B2	10/2011	Diab et al.
8,046,042	B2	10/2011	Diab et al.
8,048,040	B2	11/2011	Kiani
8,050,728	B2	11/2011	Al-Ali et al.
RE43,169	E	2/2012	Parker
8,118,620	B2	2/2012	Al-Ali et al.
8,126,528	B2	2/2012	Diab et al.
8,128,572	B2	3/2012	Diab et al.
8,130,105	B2	3/2012	Al-Ali et al.
8,145,287	B2	3/2012	Diab et al.
8,150,487	B2	4/2012	Diab et al.
8,175,672	B2	5/2012	Parker
8,180,420	B2	5/2012	Diab et al.
8,182,443	B1	5/2012	Kiani
8,185,180	B2	5/2012	Diab et al.
8,190,223	B2	5/2012	Al-Ali et al.
8,190,227	B2	5/2012	Diab et al.
8,203,438	B2	6/2012	Kiani et al.
8,203,704	B2	6/2012	Merritt et al.
8,204,566	B2	6/2012	Schurman et al.
8,219,172	B2	7/2012	Schurman et al.
8,224,411	B2	7/2012	Al-Ali et al.
8,228,181	B2	7/2012	Al-Ali
8,229,533	B2	7/2012	Diab et al.
8,233,955	B2	7/2012	Al-Ali et al.
8,244,325	B2	8/2012	Al-Ali et al.
8,255,026	B1	8/2012	Al-Ali
8,255,027	B2	8/2012	Al-Ali et al.
8,255,028	B2	8/2012	Al-Ali et al.
8,260,577	B2	9/2012	Weber et al.
8,265,723	B1	9/2012	McHale et al.
8,274,360	B2	9/2012	Sampath et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,301,217	B2	10/2012	Al-Ali et al.
8,306,596	B2	11/2012	Schurman et al.
8,310,336	B2	11/2012	Muhsin et al.
8,315,683	B2	11/2012	Al-Ali et al.
RE43,860	E	12/2012	Parker
8,337,403	B2	12/2012	Al-Ali et al.
8,346,330	B2	1/2013	Lamego
8,353,842	B2	1/2013	Al-Ali et al.
8,355,766	B2	1/2013	Macneish, III et al.
8,359,080	B2	1/2013	Diab et al.
8,364,223	B2	1/2013	Al-Ali et al.
8,364,226	B2	1/2013	Diab et al.
8,374,665	B2	2/2013	Lamego
8,385,995	B2	2/2013	Al-Ali et al.
8,385,996	B2	2/2013	Smith et al.
8,388,353	B2	3/2013	Kiani et al.
8,399,822	B2	3/2013	Al-Ali
8,401,602	B2	3/2013	Kiani
8,405,608	B2	3/2013	Al-Ali et al.
8,414,499	B2	4/2013	Al-Ali et al.
8,418,524	B2	4/2013	Al-Ali
8,423,106	B2	4/2013	Lamego et al.
8,428,967	B2	4/2013	Olsen et al.
8,430,817	B1	4/2013	Al-Ali et al.
8,437,825	B2	5/2013	Dalvi et al.
8,455,290	B2	6/2013	Siskavich
8,457,703	B2	6/2013	Al-Ali
8,457,707	B2	6/2013	Kiani
8,463,349	B2	6/2013	Diab et al.
8,466,286	B2	6/2013	Bellott et al.
8,471,713	B2	6/2013	Poeze et al.
8,473,020	B2	6/2013	Kiani et al.
8,483,787	B2	7/2013	Al-Ali et al.
8,489,364	B2	7/2013	Weber et al.
8,498,684	B2	7/2013	Weber et al.
8,504,128	B2	8/2013	Blank et al.
8,509,867	B2	8/2013	Workman et al.
8,515,509	B2	8/2013	Bruinsma et al.
8,523,781	B2	9/2013	Al-Ali
8,529,301	B2	9/2013	Al-Ali et al.
8,532,727	B2	9/2013	Ali et al.
8,532,728	B2	9/2013	Diab et al.
D692,145	S	10/2013	Al-Ali et al.
8,547,209	B2	10/2013	Kiani et al.
8,548,548	B2	10/2013	Al-Ali
8,548,549	B2	10/2013	Schurman et al.
8,548,550	B2	10/2013	Al-Ali et al.
8,560,032	B2	10/2013	Al-Ali et al.
8,560,034	B1	10/2013	Diab et al.
8,570,167	B2	10/2013	Al-Ali
8,570,503	B2	10/2013	Vo et al.
8,571,617	B2	10/2013	Reichgott et al.
8,571,618	B1	10/2013	Lamego et al.
8,571,619	B2	10/2013	Al-Ali et al.
8,577,431	B2	11/2013	Lamego et al.
8,581,732	B2	11/2013	Al-Ali et al.
8,584,345	B2	11/2013	Al-Ali et al.
8,588,880	B2	11/2013	Abdul-Hafiz et al.
8,600,467	B2	12/2013	Al-Ali et al.
8,606,342	B2	12/2013	Diab
8,626,255	B2	1/2014	Al-Ali et al.
8,630,691	B2	1/2014	Lamego et al.
8,634,889	B2	1/2014	Al-Ali et al.
8,641,631	B2	2/2014	Sierra et al.
8,652,060	B2	2/2014	Al-Ali
8,663,107	B2	3/2014	Kiani
8,666,468	B1	3/2014	Al-Ali
8,667,967	B2	3/2014	Al-Ali et al.
8,670,811	B2	3/2014	O'Reilly
8,670,814	B2	3/2014	Diab et al.
8,676,286	B2	3/2014	Weber et al.
8,682,407	B2	3/2014	Al-Ali
RE44,823	E	4/2014	Parker
RE44,875	E	4/2014	Kiani et al.
8,690,799	B2	4/2014	Telfort et al.
8,700,112	B2	4/2014	Kiani
8,702,627	B2	4/2014	Telfort et al.
8,706,179	B2	4/2014	Parker
8,712,494	B1	4/2014	MacNeish, III et al.
8,715,206	B2	5/2014	Telfort et al.
8,718,735	B2	5/2014	Lamego et al.
8,718,737	B2	5/2014	Diab et al.
8,718,738	B2	5/2014	Blank et al.
8,720,249	B2	5/2014	Al-Ali
8,721,541	B2	5/2014	Al-Ali et al.
8,721,542	B2	5/2014	Al-Ali et al.
8,723,677	B1	5/2014	Kiani
8,740,792	B1	6/2014	Kiani et al.
8,754,776	B2	6/2014	Poeze et al.
8,755,535	B2	6/2014	Telfort et al.
8,755,856	B2	6/2014	Diab et al.
8,755,872	B1	6/2014	Marinow
8,761,850	B2	6/2014	Lamego
8,764,671	B2	7/2014	Kiani
8,768,423	B2	7/2014	Shakespeare et al.
8,771,204	B2	7/2014	Telfort et al.
8,777,634	B2	7/2014	Kiani et al.
8,781,543	B2	7/2014	Diab et al.
8,781,544	B2	7/2014	Al-Ali et al.
8,781,549	B2	7/2014	Al-Ali et al.
8,788,003	B2	7/2014	Schurman et al.
8,790,268	B2	7/2014	Al-Ali
8,801,613	B2	8/2014	Al-Ali et al.
8,821,397	B2	9/2014	Al-Ali et al.
8,821,415	B2	9/2014	Al-Ali et al.
8,830,449	B1	9/2014	Lamego et al.
8,831,700	B2	9/2014	Schurman et al.
8,840,549	B2	9/2014	Al-Ali et al.
8,847,740	B2	9/2014	Kiani et al.
8,849,365	B2	9/2014	Smith et al.
8,852,094	B2	10/2014	Al-Ali et al.
8,852,994	B2	10/2014	Wojtczuk et al.
8,868,147	B2	10/2014	Stippick et al.
8,868,150	B2	10/2014	Al-Ali et al.
8,870,792	B2	10/2014	Al-Ali et al.
8,886,271	B2	11/2014	Kiani et al.
8,888,539	B2	11/2014	Al-Ali et al.
8,888,708	B2	11/2014	Diab et al.
8,892,180	B2	11/2014	Weber et al.
8,897,847	B2	11/2014	Al-Ali
8,909,310	B2	12/2014	Lamego et al.
8,911,377	B2	12/2014	Al-Ali
8,912,909	B2	12/2014	Al-Ali et al.
8,920,317	B2	12/2014	Al-Ali et al.
8,921,699	B2	12/2014	Al-Ali et al.
8,922,382	B2	12/2014	Al-Ali et al.
8,929,964	B2	1/2015	Al-Ali et al.
8,942,777	B2	1/2015	Diab et al.
8,948,834	B2	2/2015	Diab et al.
8,948,835	B2	2/2015	Diab
8,965,471	B2	2/2015	Lamego
8,983,564	B2	3/2015	Al-Ali
8,989,831	B2	3/2015	Al-Ali et al.
8,996,085	B2	3/2015	Kiani et al.
8,998,809	B2	4/2015	Kiani
9,028,429	B2	5/2015	Telfort et al.
9,037,207	B2	5/2015	Al-Ali et al.
9,060,721	B2	6/2015	Reichgott et al.
9,066,666	B2	6/2015	Kiani
9,066,680	B1	6/2015	Al-Ali et al.
9,072,474	B2	7/2015	Al-Ali et al.
9,078,560	B2	7/2015	Schurman et al.
9,084,569	B2	7/2015	Weber et al.
9,095,316	B2	8/2015	Welch et al.
9,106,038	B2	8/2015	Telfort et al.
9,107,625	B2	8/2015	Telfort et al.
9,107,626	B2	8/2015	Al-Ali et al.
9,113,831	B2	8/2015	Al-Ali
9,113,832	B2	8/2015	Al-Ali
9,119,595	B2	9/2015	Lamego
9,131,881	B2	9/2015	Diab et al.
9,131,882	B2	9/2015	Al-Ali et al.
9,131,883	B2	9/2015	Al-Ali
9,131,917	B2	9/2015	Telfort et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,138,180	B1	9/2015	Coverston et al.	
9,138,182	B2	9/2015	Al-Ali et al.	
9,138,192	B2	9/2015	Weber et al.	
9,142,117	B2	9/2015	Muhsin et al.	
9,153,112	B1	10/2015	Kiani et al.	
9,153,121	B2	10/2015	Kiani et al.	
9,161,696	B2	10/2015	Al-Ali et al.	
9,161,713	B2	10/2015	Al-Ali et al.	
9,167,995	B2	10/2015	Lamego et al.	
9,176,141	B2	11/2015	Al-Ali et al.	
9,186,102	B2	11/2015	Bruinsma et al.	
9,192,312	B2	11/2015	Al-Ali	
9,192,329	B2	11/2015	Al-Ali	
9,192,351	B1	11/2015	Telfort et al.	
9,195,385	B2	11/2015	Al-Ali et al.	
9,211,072	B2	12/2015	Kiani	
9,211,095	B1	12/2015	Al-Ali	
9,218,454	B2	12/2015	Kiani et al.	
9,226,696	B2	1/2016	Kiani	
9,241,662	B2	1/2016	Al-Ali et al.	
9,245,668	B1	1/2016	Vo et al.	
9,259,185	B2	2/2016	Abdul-Hafiz et al.	
9,267,572	B2	2/2016	Barker et al.	
9,277,880	B2	3/2016	Poeze et al.	
9,289,167	B2	3/2016	Diab et al.	
9,295,421	B2	3/2016	Kiani et al.	
9,307,928	B1	4/2016	Al-Ali et al.	
9,323,894	B2	4/2016	Kiani	
D755,392	S	5/2016	Hwang et al.	
9,326,712	B1	5/2016	Kiani	
9,333,316	B2	5/2016	Kiani	
9,339,220	B2	5/2016	Lamego et al.	
9,341,565	B2	5/2016	Lamego et al.	
9,351,673	B2	5/2016	Diab et al.	
9,351,675	B2	5/2016	Al-Ali et al.	
9,364,181	B2	6/2016	Kiani et al.	
9,368,671	B2	6/2016	Wojtczuk et al.	
9,370,325	B2	6/2016	Al-Ali et al.	
9,370,326	B2	6/2016	McHale et al.	
9,370,335	B2	6/2016	Al-Ali et al.	
9,375,185	B2	6/2016	Ali et al.	
9,386,953	B2	7/2016	Al-Ali	
9,386,961	B2	7/2016	Al-Ali et al.	
9,392,945	B2	7/2016	Al-Ali et al.	
9,397,448	B2	7/2016	Al-Ali et al.	
2006/0200009	A1*	9/2006	Wekell et al.	600/300
2006/0282475	A1*	12/2006	Suermondt	G06F 17/30286
2009/0247984	A1	10/2009	Lamego et al.	
2009/0275844	A1	11/2009	Al-Ali	
2010/0004518	A1	1/2010	Vo et al.	
2010/0030040	A1	2/2010	Poeze et al.	
2010/0179394	A1*	7/2010	Sohn	A61B 5/00 600/301
2010/0261979	A1	10/2010	Kiani	
2011/0001605	A1	1/2011	Kiani et al.	
2011/0077968	A1*	3/2011	Kelly	G06F 19/345 705/3
2011/0082711	A1	4/2011	Poeze et al.	
2011/0105854	A1	5/2011	Kiani et al.	
2011/0208015	A1	8/2011	Welch et al.	
2011/0213212	A1	9/2011	Al-Ali	
2011/0230733	A1	9/2011	Al-Ali	
2011/0237911	A1	9/2011	Lamego et al.	
2012/0059267	A1	3/2012	Lamego et al.	
2012/0116175	A1	5/2012	Al-Ali et al.	
2012/0179006	A1	7/2012	Jansen et al.	
2012/0209082	A1	8/2012	Al-Ali	
2012/0209084	A1	8/2012	Olsen et al.	
2012/0227739	A1	9/2012	Kiani	
2012/0283524	A1	11/2012	Kiani et al.	
2012/0296178	A1	11/2012	Lamego et al.	
2012/0304110	A1*	11/2012	Chmiel	G06F 3/0481 715/784
2012/0319816	A1	12/2012	Al-Ali	
2012/0330112	A1	12/2012	Lamego et al.	
2013/0023775	A1	1/2013	Lamego et al.	
2013/0041591	A1	2/2013	Lamego	
2013/0045685	A1	2/2013	Kiani	
2013/0046204	A1	2/2013	Lamego et al.	
2013/0060147	A1	3/2013	Welch et al.	
2013/0096405	A1	4/2013	Garfio	
2013/0096936	A1	4/2013	Sampath et al.	
2013/0109935	A1	5/2013	Al-Ali et al.	
2013/0162433	A1	6/2013	Muhsin et al.	
2013/0190581	A1	7/2013	Al-Ali et al.	
2013/0197328	A1	8/2013	Diab et al.	
2013/0211214	A1*	8/2013	Olsen	A61B 5/742 600/316
2013/0218596	A1*	8/2013	Gome	G06Q 10/06 705/3
2013/0243021	A1	9/2013	Siskavich	
2013/0253334	A1	9/2013	Al-Ali et al.	
2013/0274571	A1	10/2013	Diab et al.	
2013/0296672	A1	11/2013	O'Neil et al.	
2013/0317370	A1	11/2013	Dalvi et al.	
2013/0324808	A1	12/2013	Al-Ali et al.	
2013/0331670	A1	12/2013	Kiani	
2013/0338461	A1	12/2013	Lamego et al.	
2014/0012100	A1	1/2014	Al-Ali et al.	
2014/0025306	A1	1/2014	Weber et al.	
2014/0034353	A1	2/2014	Al-Ali et al.	
2014/0051953	A1	2/2014	Lamego et al.	
2014/0058230	A1	2/2014	Abdul-Hafiz et al.	
2014/0066783	A1	3/2014	Kiani et al.	
2014/0077956	A1	3/2014	Sampath et al.	
2014/0081100	A1	3/2014	Muhsin et al.	
2014/0081175	A1	3/2014	Telfort	
2014/0094667	A1	4/2014	Schurman et al.	
2014/0100434	A1	4/2014	Diab et al.	
2014/0114199	A1	4/2014	Lamego et al.	
2014/0120564	A1	5/2014	Workman et al.	
2014/0121482	A1	5/2014	Merritt et al.	
2014/0121483	A1	5/2014	Kiani	
2014/0127137	A1	5/2014	Bellott et al.	
2014/0128696	A1	5/2014	Al-Ali	
2014/0128699	A1	5/2014	Al-Ali et al.	
2014/0129702	A1	5/2014	Lamego et al.	
2014/0135588	A1	5/2014	Al-Ali et al.	
2014/0142401	A1	5/2014	Al-Ali et al.	
2014/0142402	A1	5/2014	Al-Ali et al.	
2014/0163344	A1	6/2014	Al-Ali	
2014/0163402	A1	6/2014	Lamego et al.	
2014/0166076	A1	6/2014	Kiani et al.	
2014/0171763	A1	6/2014	Diab	
2014/0180038	A1	6/2014	Kiani	
2014/0180154	A1	6/2014	Sierra et al.	
2014/0194709	A1	7/2014	Al-Ali et al.	
2014/0194711	A1	7/2014	Al-Ali	
2014/0194766	A1	7/2014	Al-Ali et al.	
2014/0206963	A1	7/2014	Al-Ali	
2014/0213864	A1	7/2014	Abdul-Hafiz et al.	
2014/0243627	A1	8/2014	Diab et al.	
2014/0266790	A1	9/2014	Al-Ali et al.	
2014/0275808	A1	9/2014	Poeze et al.	
2014/0275835	A1	9/2014	Lamego et al.	
2014/0275871	A1	9/2014	Lamego et al.	
2014/0275872	A1	9/2014	Merritt et al.	
2014/0275881	A1	9/2014	Lamego et al.	
2014/0288400	A1	9/2014	Diab et al.	
2014/0296664	A1	10/2014	Bruinsma et al.	
2014/0303520	A1	10/2014	Telfort et al.	
2014/0309506	A1	10/2014	Lamego et al.	
2014/0316228	A1	10/2014	Blank et al.	
2014/0323825	A1	10/2014	Al-Ali et al.	
2014/0330092	A1	11/2014	Al-Ali et al.	
2014/0330098	A1	11/2014	Merritt et al.	
2014/0330099	A1	11/2014	Al-Ali et al.	
2014/0333440	A1	11/2014	Kiani	
2014/0336481	A1	11/2014	Shakespeare et al.	
2014/0343436	A1	11/2014	Kiani	
2015/0018650	A1	1/2015	Al-Ali et al.	
2015/0351697	A1	12/2015	Weber et al.	
2015/0351704	A1	12/2015	Kiani et al.	
2015/0359429	A1	12/2015	Al-Ali et al.	

(56) **References Cited**

U.S. PATENT DOCUMENTS

2015/0366472	A1	12/2015	Kiani
2015/0366507	A1	12/2015	Blank
2015/0374298	A1	12/2015	Al-Ali et al.
2015/0380875	A1	12/2015	Coverston et al.
2016/0000362	A1	1/2016	Diab et al.
2016/0007930	A1	1/2016	Weber et al.
2016/0029932	A1	2/2016	Al-Ali
2016/0029933	A1	2/2016	Al-Ali et al.
2016/0045118	A1	2/2016	Kiani
2016/0051205	A1	2/2016	Al-Ali et al.
2016/0058338	A1	3/2016	Schurman et al.
2016/0058347	A1	3/2016	Reichgott et al.
2016/0066823	A1	3/2016	Al-Ali et al.
2016/0066824	A1	3/2016	Al-Ali et al.
2016/0066879	A1	3/2016	Telfort et al.
2016/0072429	A1	3/2016	Kiani et al.
2016/0073967	A1	3/2016	Lamego et al.
2016/0081552	A1	3/2016	Wojtczuk et al.
2016/0095543	A1	4/2016	Telfort et al.
2016/0095548	A1	4/2016	Al-Ali et al.
2016/0103598	A1	4/2016	Al-Ali et al.
2016/0113527	A1	4/2016	Al-Ali
2016/0143548	A1	5/2016	Al-Ali
2016/0166183	A1	6/2016	Poeze et al.
2016/0166188	A1	6/2016	Bruinsma et al.
2016/0166210	A1	6/2016	Al-Ali
2016/0192869	A1	7/2016	Kiani et al.
2016/0196388	A1	7/2016	Lamego
2016/0197436	A1	7/2016	Barker et al.
2016/0213281	A1	7/2016	Eckerbom et al.

OTHER PUBLICATIONS

Lorincz, Konrad, et al. "Sensor Networks for Emergency Response: Challenges and Opportunities." Pervasive Computing, IEEE 3.4 (2004): 16-23.*

Gao, Tia, et al. "Wireless Medical Sensor Networks in Emergency Response: Implementation and Pilot Results." Technologies for Homeland Security, 2008 IEEE Conference on. IEEE, 2008.*

* cited by examiner

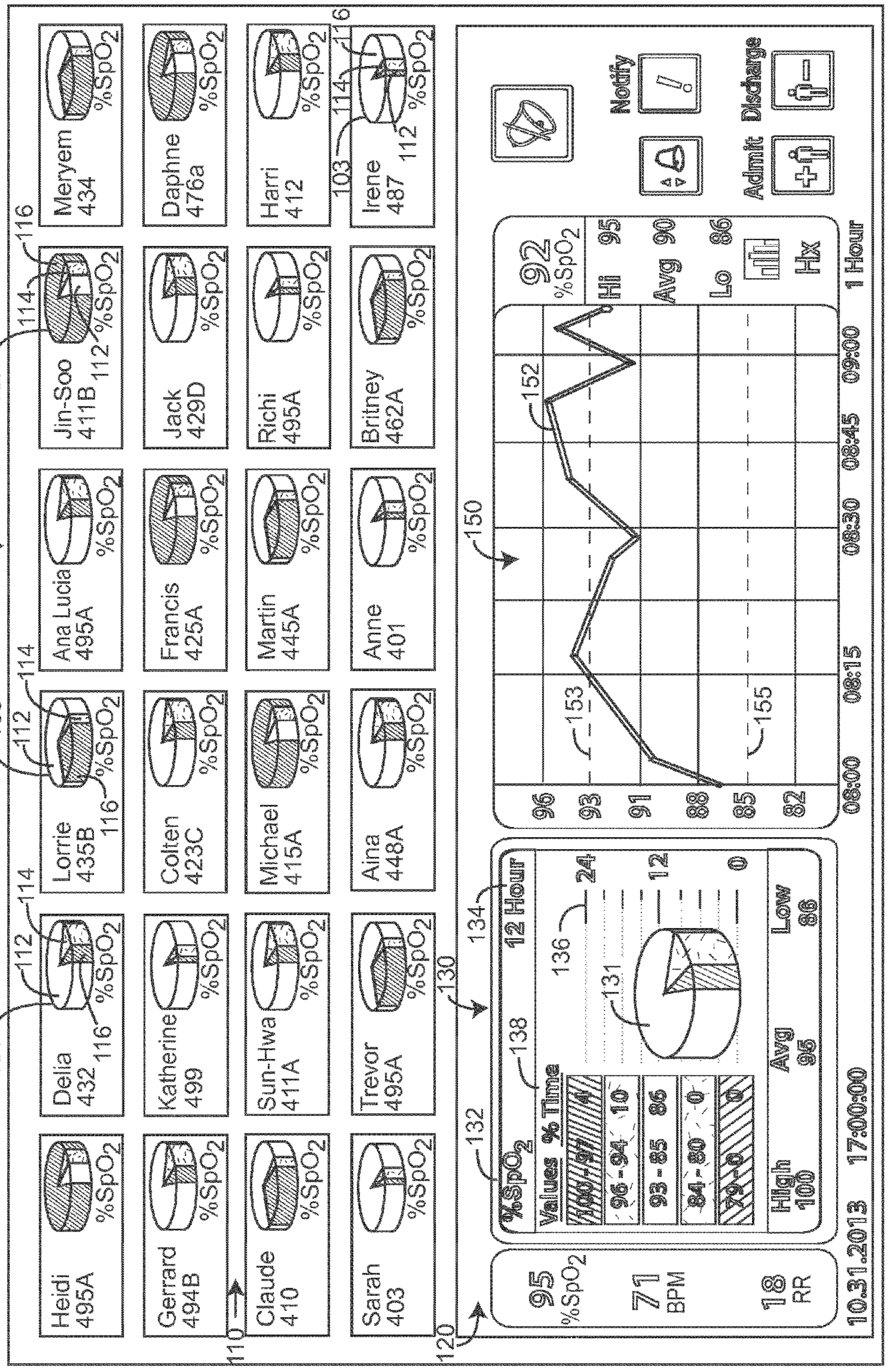

100
101
105
107
110
120
130
132
134
150
152
153
155
Meryem 434
Daphne 476a
Harri 412
Irene 487
Jin-Soo 411B
Jack 429D
Richi 495A
Britney 462A
Ana Lucia 495A
Francis 425A
Martin 445A
Anne 401
Lorrie 435B
Colten 423C
Michael 415A
Aina 448A
Delia 432
Katherine 499
Sun-Hwa 411A
Trevor 495A
Heidi 495A
Gerrard 494B
Claude 410
Sarah 403
%SpO2
Notify
Admit
Discharge
92 %SpO2
Hi 95
Avg 90
Lo 86
Hx
1 Hour
08:00
08:15
08:30
08:45
09:00
96
93
91
88
85
82
12 Hour
24
12
0
Low 86
Avg 95
Values
% Time
96 - 94 10
93 - 85 86
84 - 80 0
79 - 0 4
High 100
95 %SpO2
71 BPM
18 RR
10.31.2013 17:00:00

FIG. 1

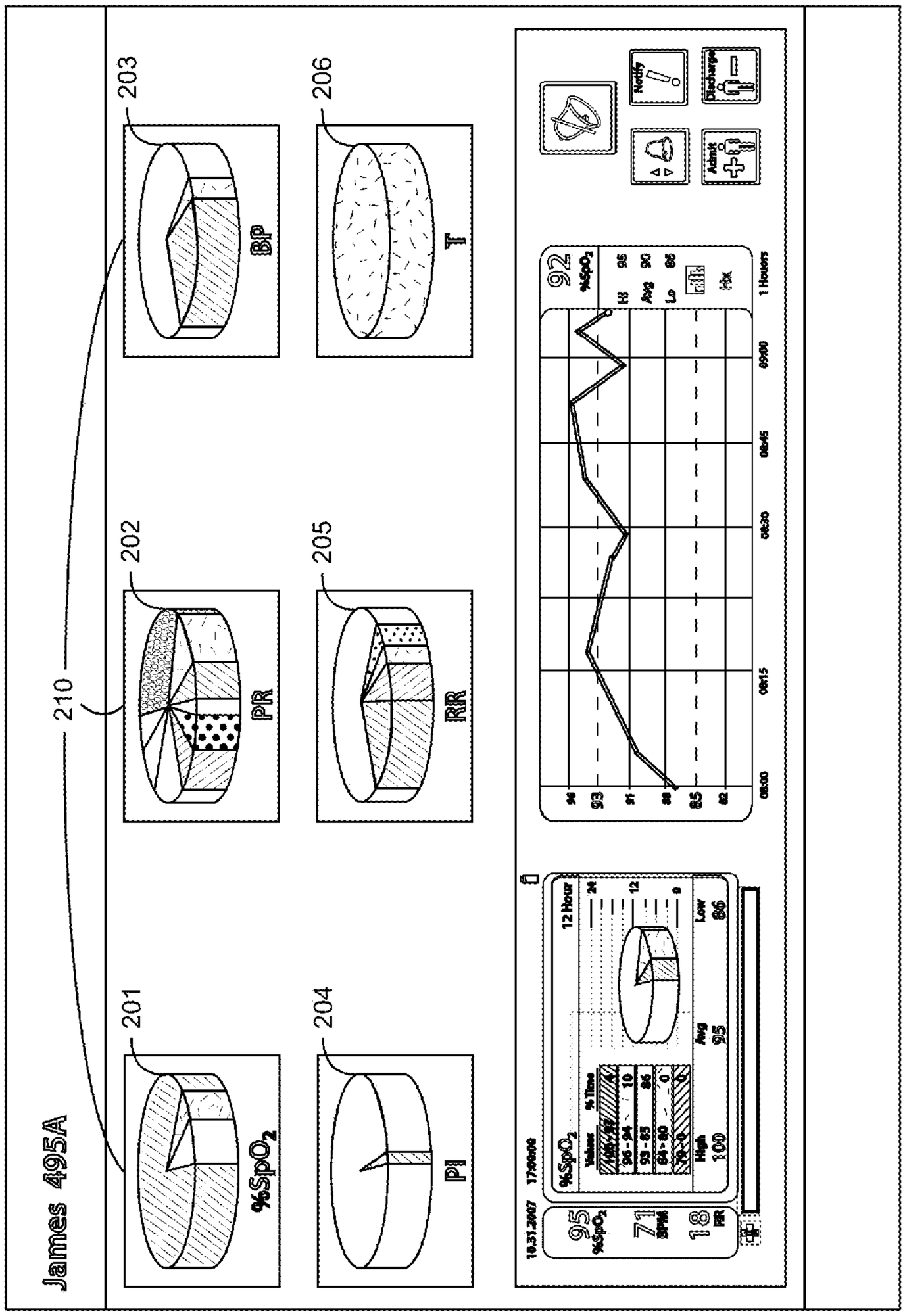

200
210
203
206
202
205
201
204
BP
T
PR
RR
%SpO2
PI
James 495A
Notify
Discharge
Admit
92
%SpO2
Hi 95
Avg 90
Lo 86
mth
Hrs
1 Hours
96
93
91
88
85
82
08:00
08:15
08:30
08:45
09:00
12 Hour
24
12
0
Low
86
Avg
95
%SpO2
% Time
Values
96 - 94
93 - 85
84 - 80
79 - 0
10
85
0
0
High
100
10.31.2007
17:00:00
95
%SpO2
71
BPM
18
RR

FIG. 2

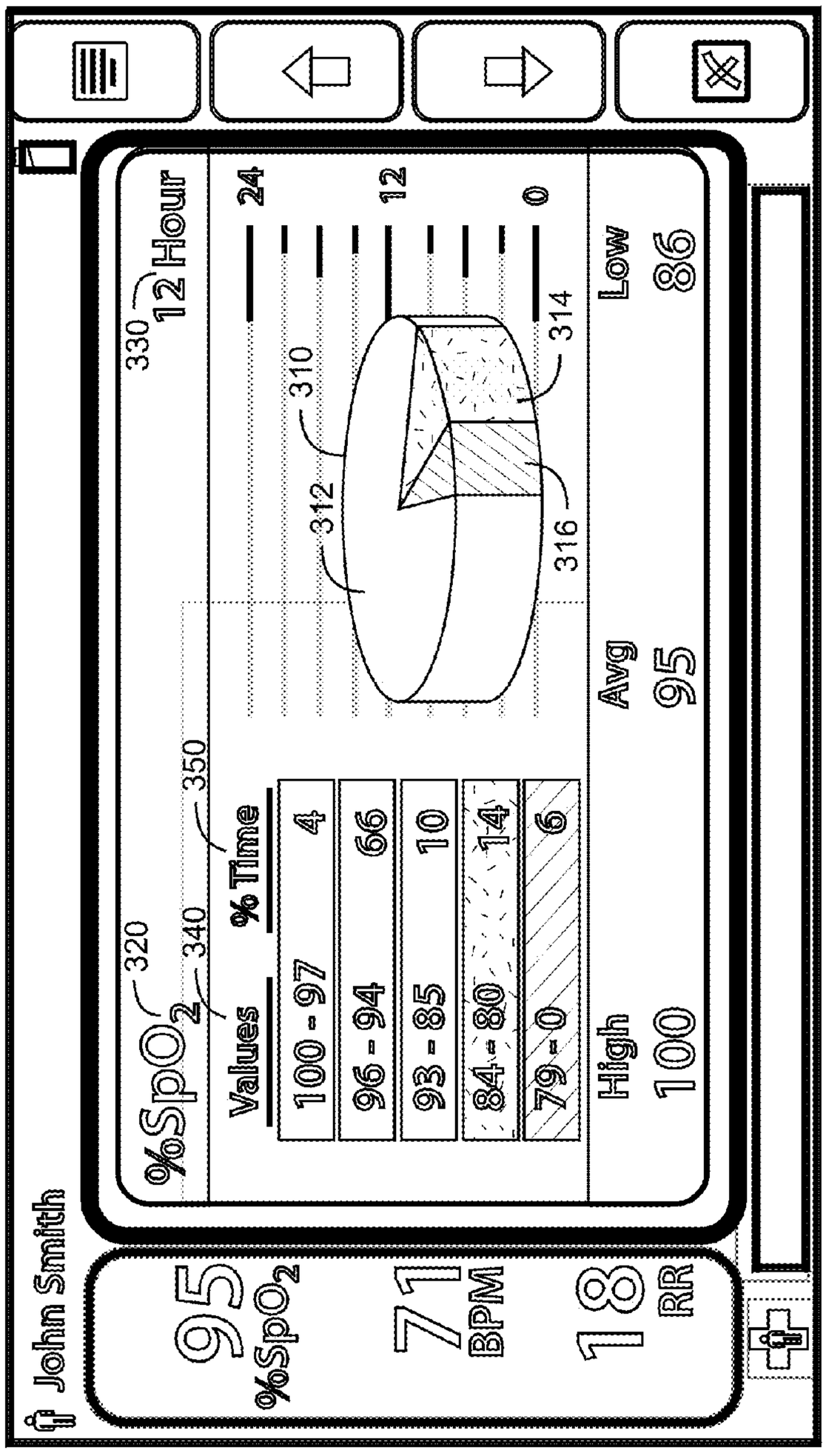

300
John Smith
95
%SpO2
71
BPM
18
RR
%SpO2
12 Hour
330
320
340
350
Values
% Time
100 - 97
4
96 - 94
66
93 - 85
10
84 - 80
14
79 - 0
6
310
312
314
316
High
100
Avg
95
Low
86

FIG. 3

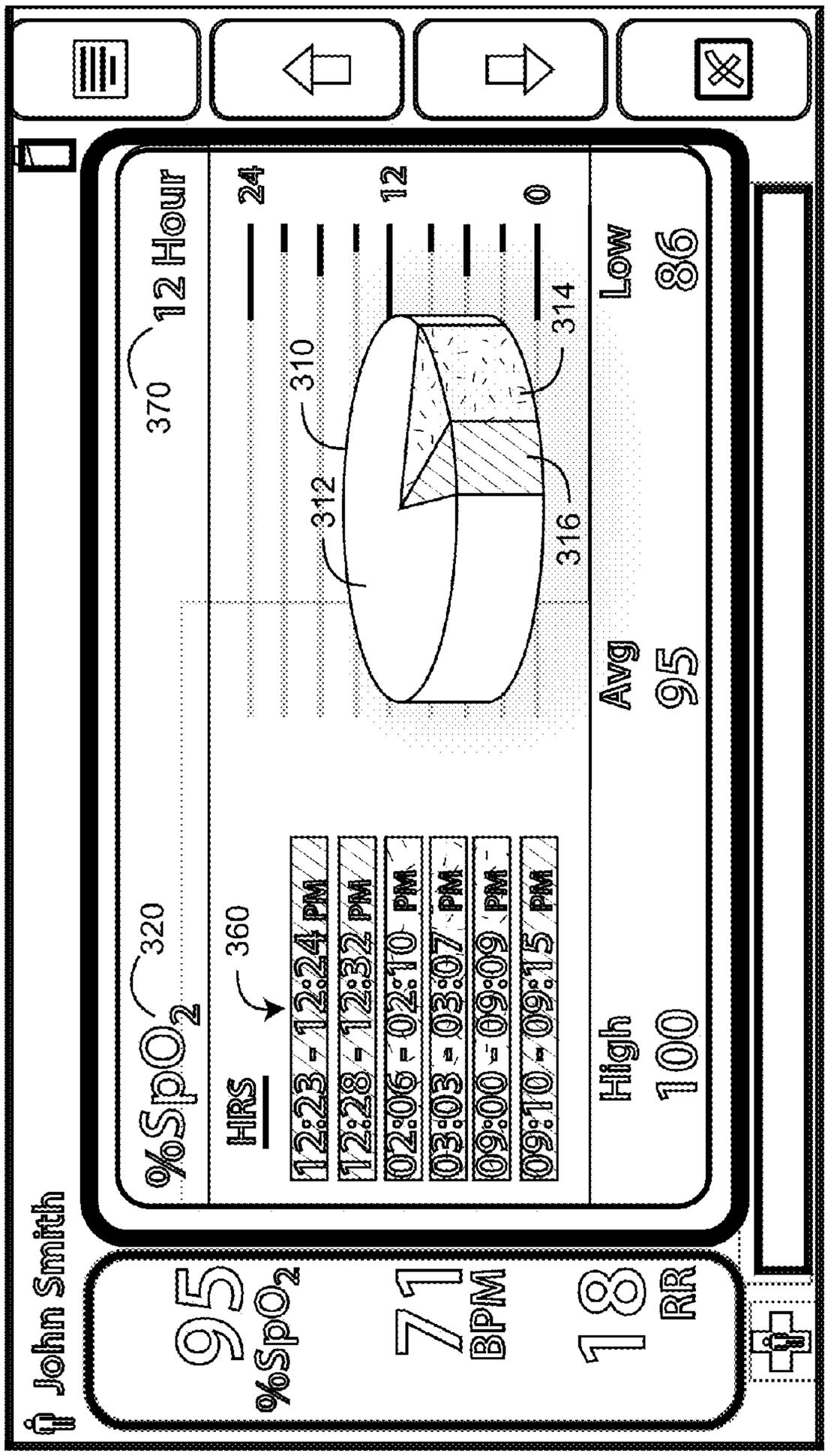

301
John Smith
95 %SpO2
71 BPM
18 RRR
%SpO2
320
360
HRS
12:23 - 12:24 PM
12:28 - 12:32 PM
02:06 - 02:10 PM
03:03 - 03:07 PM
09:00 - 09:09 PM
09:10 - 09:15 PM
370
12 Hour
24
12
0
310
312
314
316
High
100
Avg
95
Low
86

FIG. 4

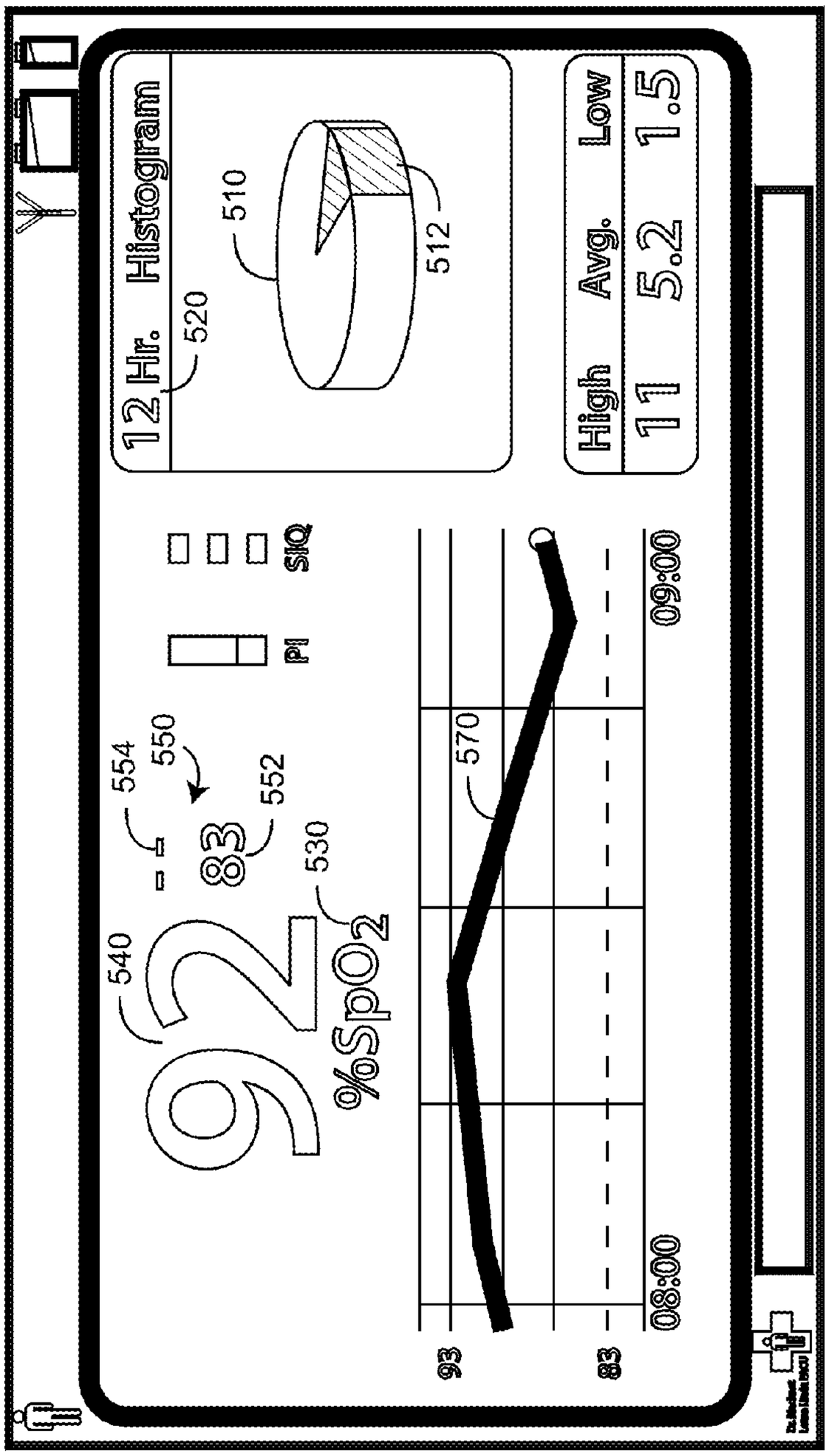

500
12 Hr.
Histogram
520
510
512
Avg.
Low
5.2
1.5
High
11
SIQ
PI
554
550
552
83
530
92
%SpO2
540
570
09:00
08:00
93
83

FIG. 5

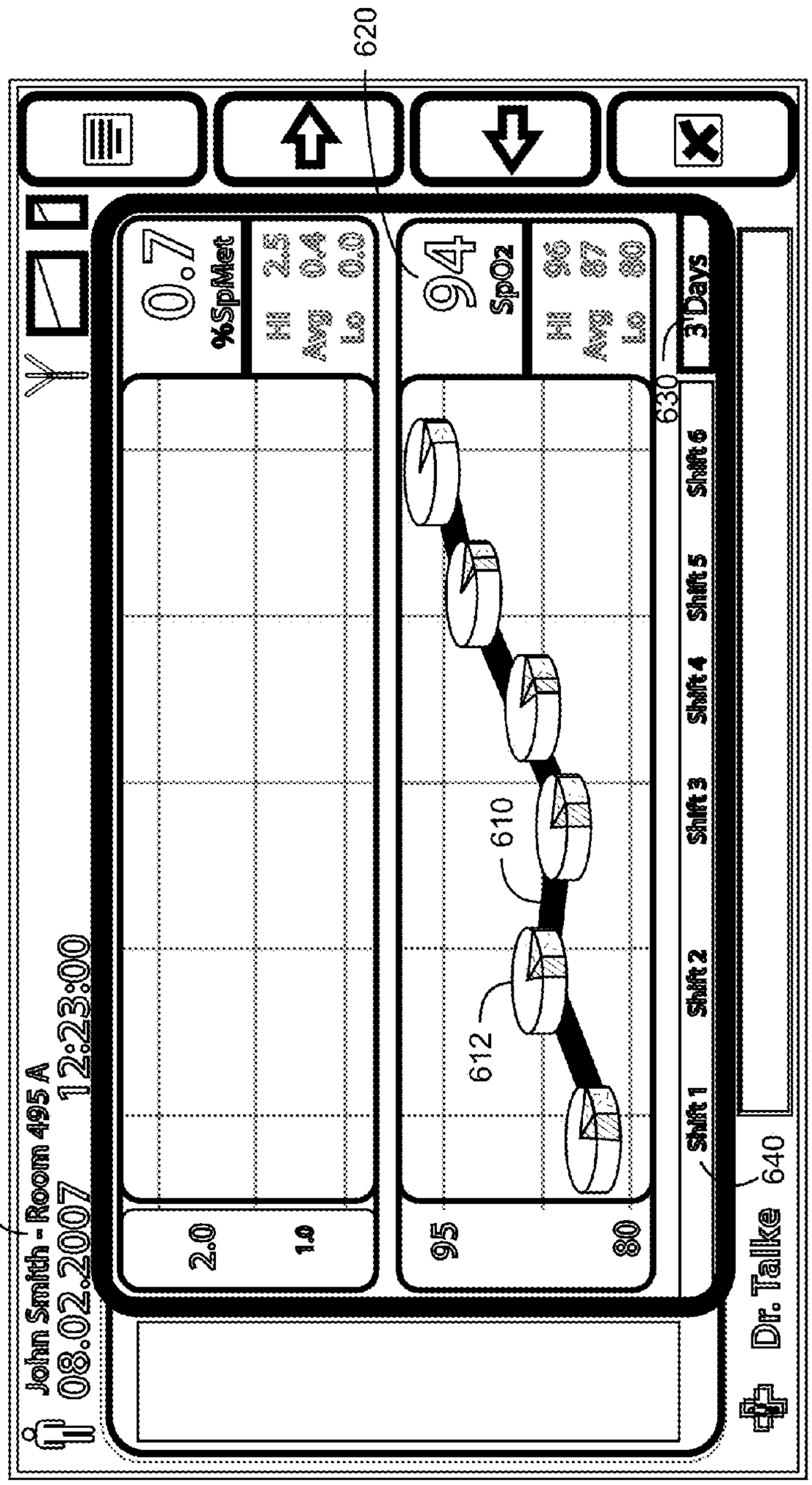

600
620
630
640
610
612
0.7
%SpMet
Hi 2.5
Avg 0.4
Lo 0.0
94
SpO2
Hi 86
Avg 87
Lo 80
3 Days
2.0
1.9
95
80
Shift 1
Shift 2
Shift 3
Shift 4
Shift 5
Shift 6
John Smith - Room 495 A
08.02.2007 12:23:00
Dr. Talke

FIG. 6

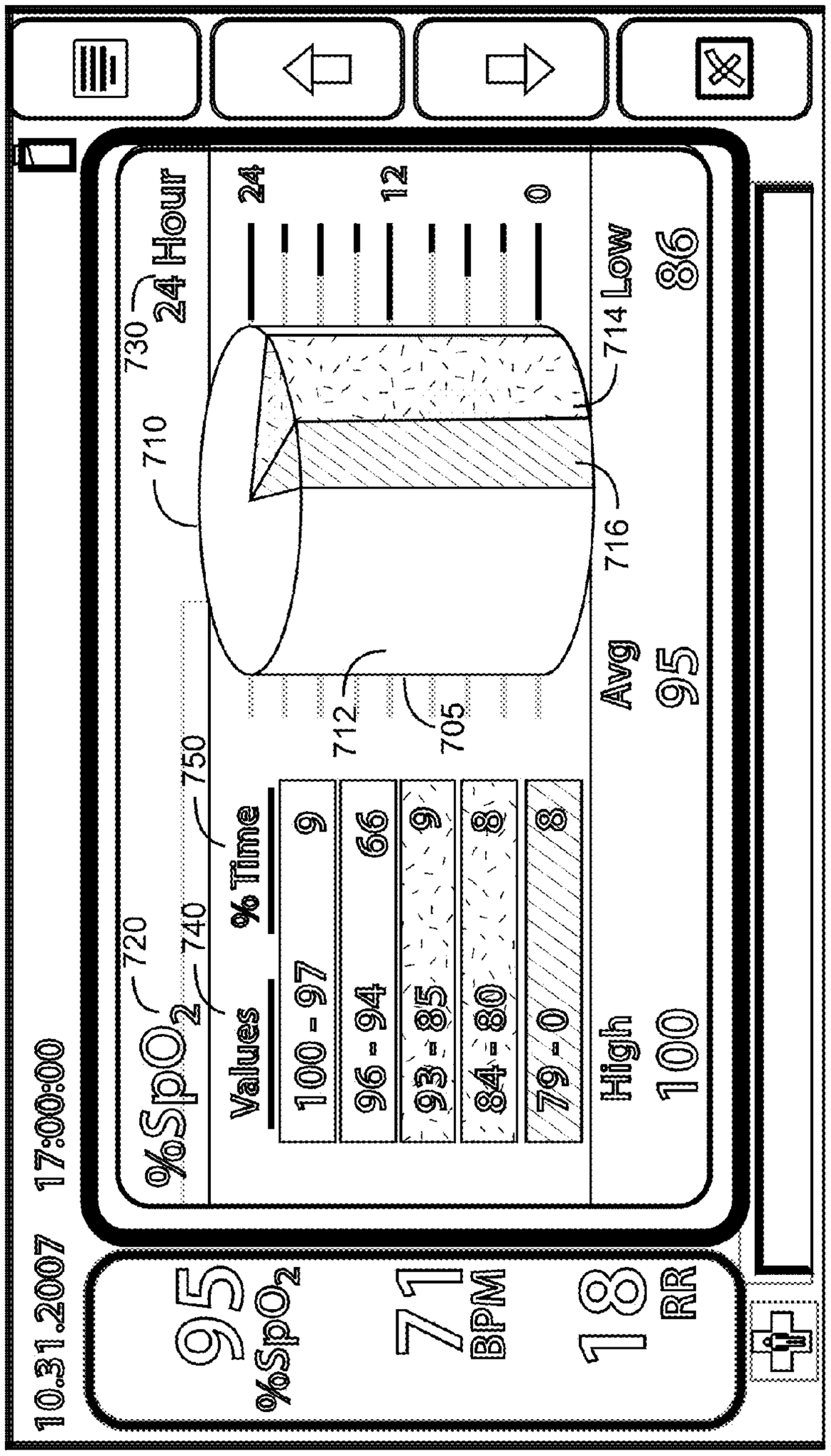

700
10.31.2007
17:00:00
%SpO2
720
740
750
Values
% Time
100 - 97 9
96 - 94 66
93 - 85 9
84 - 80 8
79 - 0 8
24 Hour
730
710
712
705
716
714 Low
High 100
Avg 95
Low 86
95 %SpO2
71 BPM
18 RR

FIG. 7

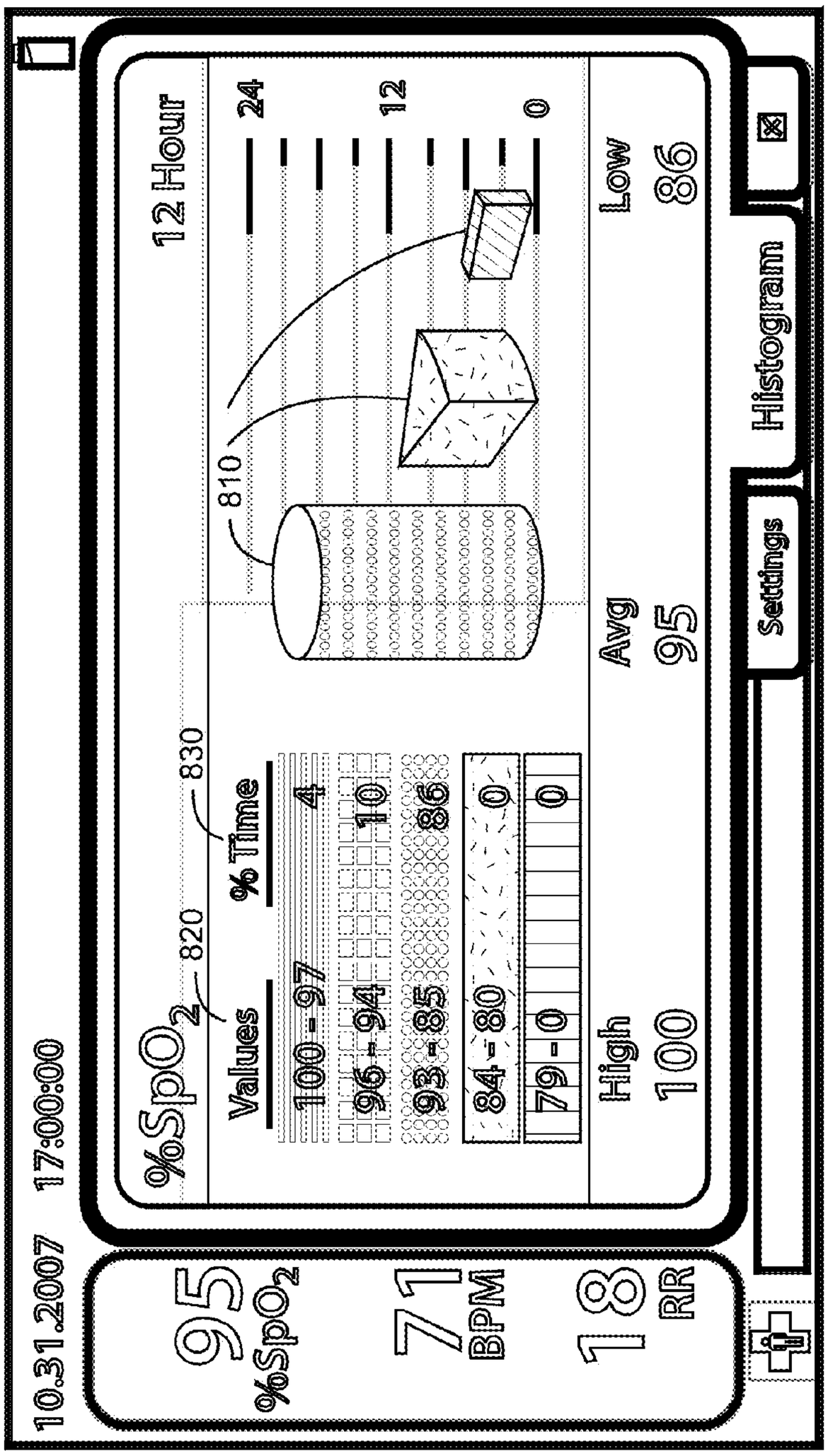

800
10.31.2007
17:00:00
12 Hour
24
12
0
Low
86
Histogram
Settings
810
820
830
%SpO2
Values
% Time
100 - 97
4
96 - 94
10
93 - 85
86
84 - 80
0
79 - 0
0
High
100
Avg
95
95
%SpO2
71
BPM
18
RR

FIG. 8

PHYSIOLOGICAL STATUS MONITOR

PRIORITY CLAIM TO RELATED PROVISIONAL APPLICATION

The present application claims priority benefit under 35 U.S.C. §119(e) to U.S. Provisional Patent Application Ser. No. 61/775,568 filed Mar. 9, 2013, titled Physiological Status Monitor. The above-cited provisional patent application is hereby incorporated in its entirety by reference herein.

BACKGROUND OF THE INVENTION

Pulse oximetry is a widely accepted noninvasive procedure for measuring the oxygen saturation level of arterial blood, an indicator of a person's oxygen supply. A typical pulse oximetry system utilizes an optical sensor attached to a fingertip to measure the relative volume of oxygenated hemoglobin in pulsatile arterial blood flowing within the fingertip. Oxygen saturation (SpO_2), pulse rate and a plethysmograph waveform, which is a visualization of pulsatile blood flow over time, are displayed on a monitor accordingly.

Conventional pulse oximetry assumes that arterial blood is the only pulsatile blood flow in the measurement site. During patient motion, venous blood also moves, which causes errors in conventional pulse oximetry. Advanced pulse oximetry processes the venous blood signal so as to report true arterial oxygen saturation and pulse rate under conditions of patient movement. Advanced pulse oximetry also functions under conditions of low perfusion (small signal amplitude), intense ambient light (artificial or sunlight) and electrosurgical instrument interference, which are scenarios where conventional pulse oximetry tends to fail.

Advanced pulse oximetry is described in at least U.S. Pat. Nos. 6,770,028; 6,658,276; 6,157,850; 6,002,952; 5,769,785 and 5,758,644, which are assigned to Masimo Corporation ("Masimo") of Irvine, Calif. and are incorporated in their entirety by reference herein. Corresponding low noise optical sensors are disclosed in at least U.S. Pat. Nos. 6,985,764; 6,813,511; 6,792,300; 6,256,523; 6,088,607; 5,782,757 and 5,638,818, which are also assigned to Masimo and are also incorporated in their entirety by reference herein. Advanced pulse oximetry systems including Masimo SET® low noise optical sensors and read through motion pulse oximetry monitors for measuring SpO_2, pulse rate (PR) and perfusion index (PI) are available from Masimo. Optical sensors include any of Masimo LNOP®, LNCS®, SofTouch™ and Blue™ adhesive or reusable sensors. Pulse oximetry monitors include any of Masimo Rad-8®, Rad-5®, Rad®-5v or SatShare® monitors.

Advanced blood parameter measurement systems are described in at least U.S. Pat. No. 7,647,083, filed Mar. 1, 2006, titled Multiple Wavelength Sensor Equalization; U.S. Pat. No. 7,729,733, filed Mar. 1, 2006, titled Configurable Physiological Measurement System; U.S. Pat. Pub. No. 2006/0211925, filed Mar. 1, 2006, titled Physiological Parameter Confidence Measure and U.S. Pat. Pub. No. 2006/0238358, filed Mar. 1, 2006, titled Noninvasive Multi-Parameter Patient Monitor, all assigned to Cercacor Laboratories, Inc., Irvine, Calif. (Cercacor) and all incorporated in their entirety by reference herein. Advanced blood parameter measurement systems include Masimo Rainbow® SET, which provides measurements in addition to SpO_2, such as total hemoglobin (SpHb™), oxygen content (SpOC™), methemoglobin (SpMet®), carboxyhemoglobin (SpCO®) and PVI®. Advanced blood parameter sensors include Masimo Rainbow® adhesive, ReSposable™ and reusable sensors. Advanced blood parameter monitors include Masimo Radical-7™, Rad-87™ and Rad-57™, Pronto-7® and Pronto® monitors, all available from Masimo. Such advanced pulse oximeters, low noise sensors and advanced blood parameter systems have gained rapid acceptance in a wide variety of medical applications, including surgical wards, intensive care and neonatal units, general wards, home care, physical training, and virtually all types of monitoring scenarios.

SUMMARY OF THE INVENTION

Advantageously, a physiological status monitor provides information that allows a medical practitioner to visually discern patient condition at a glance. In an embodiment, a colored historical pie chart for a critical parameter, such as oxygen saturation, can be displayed for multiple patients. In another embodiment, multiple historical pie charts are displayed, depicting various parameters for a single patient so as to allow assessment of real time data and duration of time spent in various ranges. In particular, colored historical pie charts reflect visual representations of parameter histograms. Furthermore, colored pie charts may also represent alarm histories or medical personnel shifts.

One aspect of a physiological status monitor displays historical physical information of patients side by side, visually compares the information and identifies patients in need of immediate medical attention. In various embodiments, the display divides the information into medical conditions including a normal condition and a serious condition and distinguishes the conditions with indicators. Comparing may comprise viewing the indicators and discerning a serious condition with an indicator representing a particular serious condition. Identifying may comprise determining a patient having a high percentage of a serious condition indicator as the one in need of immediate medical attention. A particular condition may be oxygen saturation status. Distinguishing may comprise assigning colors to the conditions or assigning objects to the conditions.

Another aspect of a physiological status monitor is a monitor having an interconnected sensor. The sensor transmits optical radiation into a tissue site and generates a sensor signal responsive to the optical radiation after attenuation by pulsatile blood flow within the tissue site. The monitor computes a physiological parameter responsive to the sensor signal and utilizes a display to show the physiological parameter on screen. In an embodiment, the physiological status monitor comprises a monitor that determines a physiological parameter in response to an optical sensor signal derived from patients, a display incorporated with the monitor so as to present the physiological parameter, objects representing historical information regarding the physiological parameter over patients and a preferred screen presenting the objects side by side on the display for viewing by a caregiver so that the caregiver can visually discern and readily identify patients in need of immediate medical attention.

In various embodiments, the objects are colored pie charts. Each of the pie charts have zones representing different medical conditions, wherein the zones are assigned colors to make a visual distinction. The physiological parameter is oxygen saturation. The colors comprise a green color indicating a normal condition, an orange color indicating an abnormal condition and a red color indicating a serious condition, wherein a patient corresponding to one of

the pie charts having the most percentage of the red color is in need of a immediate medical attention. The objects are different shapes, wherein the shapes are filled in lines, dots, circle and square patterns to make a distinction for a color blind user.

As used herein the term "display" is used to denote how a monitor screen appears on a physical monitor device. The term "monitor" is used as shorthand for a monitor screen and its associated appearance to someone viewing a physical monitor.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an illustration of a multiple-patient and a selected-patient physiological status monitor displaying a critical parameter, such as oxygen saturation, over time;

FIG. **2** is an illustration of a single-patient physiological status monitor displaying multiple parameters, such as oxygen saturation, pulse rate, blood pressure, perfusion index, respiration rate and temperature over time;

FIG. **3** is an illustration of a single-patient, single-parameter physiological status monitor displaying a parameter over time, where the pie chart colors correspond to assigned ranges for the parameter;

FIG. **4** is an illustration of a single-patient, single-parameter physiological status monitor displaying time intervals that correspond to pie chart segments;

FIG. **5** is an illustration of a single-patient, multiple-parameter physiological monitor displaying parameter alarm limits;

FIG. **6** is an illustration of a single-patient, single-parameter physiological status monitor displaying parameter trends having integrated pie-chart summaries at specific time intervals;

FIG. **7** is an illustration of a single-patient, single-parameter physiological status monitor displaying a pie-chart having a height that represents the total monitored time interval and pie slices that each represent the percentage of time a parameter is within the specified value range; and

FIG. **8** is an illustration of single-patient, single-parameter physiological status monitor displaying iconic patterns utilized in lieu of colors, such as for a color blind user, a monochromatic display or high contrast display applications.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** illustrates a physiological status monitor **100** having a multiple-patient display **110** and a selected-patient display **120** of a critical parameter, such as oxygen saturation, over time. Historical information of a critical parameter over a duration of time is advantageously displayed for multiple patients simultaneously so as to allow a caregiver to visually discern and readily identify one or more patients in need of immediate medical attention. Advantageously, multiple colored historical pie charts **110** are advantageously utilized to represent the historical information. In an embodiment, each pie chart **110** has zones **112**, **114**, **116** representing the percentage of time a parameter has been measured in a particular range of values. Each zone **112**, **114**, **116** is assigned a different color indicating a different medical condition so that a relative comparison is made by simply viewing the size of a particular slice. For example, a pie chart **110** having a large red slice may indicate the corresponding patient has been experiencing difficulties and is in need of immediate medical attention.

As shown in FIG. **1**, the exemplar parameter depicted in the pie charts **110** is oxygen saturation (SpO_2). In other embodiments, the display **100** may depict any of various alternative parameters, such as those described above and with respect to FIG. **2**, below. In an embodiment, each pie chart **110** has a first zone **112** assigned to a safe green color indicating a normal oxygen saturation condition, a second zone **114** assigned to an orange color indicating an abnormal oxygen saturation condition and a third zone **116** assigned to a warning red color indicating a serious oxygen saturation condition. A normal patient condition is advantageously identified when the first zone **112** (green) is the largest slice of a pie chart, with the second zone **114** (orange) and the third zone **116** (red) being significantly smaller slices, such as shown with respect to pie charts **101** and **103**. That is, patients represented by the pie charts **101**, **103** are in a normal condition over most of a specified time period, such as 12 hours.

Also shown in FIG. **1**, an abnormal, but not serious, patient condition is advantageously identified when the third zone **116** (red) occupies a significant portion, but less than half, of a pie chart and the other zones **112**, **114** combined occupy more than half of the pie chart. An example is pie chart **105**, which a caregiver can readily identify at a glance as a patient needing an immediate medical assessment and further care.

Further shown in FIG. **1**, a serious patient condition is advantageously identified when the third zone **116** (red) occupies most of the pie chart, and the other two zones **112**, **114** combined occupy less of the pie chart than the third zone **116**. As example is pie chart **107**, which a caregiver can readily identify at a glance as a patient in distress and in need of emergency medical attention.

Additionally shown in FIG. **1**, a selected-patient display **120** has a pie chart **130** mini screen and a graph **150** mini screen that provide more details regarding a selected patient than are available from the multiple patient display **110**. In particular, the pie chart **130** mini screen shows details of a particular pie chart **131** including the critical parameter **132**, a duration of time **134**, a histogram **136** and range categories **138**. The range categories **138** have predetermined value ranges and corresponding percentages of time that the selected parameter **132** spent in each range. Each range **138** is assigned to a color corresponding to that in the pie chart **130**. The percentages of time spent in each range **138** over the specified time duration **134** is automatically tracked and displayed. In this manner, the details of one pie chart **131** can be viewed with respect to parameter ranges **138** that each color represents. For example, a green color in the pie chart **131** represents an SpO_2 range of 93-85, and the patient spent 86% of time spent in this range. An orange color represents an SpO_2 range of 96-94 and 84-80 and the patient spent 10% and 0% of the time in those ranges, respectively. A red color represents an SpO_2 range of 100-97 and 79-0 and the patient spent 4% and 0% of the time in those ranges, respectively.

Also shown in FIG. **1**, the selected-patient display **120** has a graph mini-screen **150** showing further details of the pie chart **131**. The graph mini-screen **150** has a graph **152** showing parameter values versus time over a period, an upper alarm limit **153** and a lower alarm limit **155**. Thus, the specific times in an alarm state are illustrated.

FIG. **2** illustrates a single-patient physiological status monitor **200** displaying multiple parameters, such as oxygen saturation, pulse rate, blood pressure, perfusion index, respiration rate and temperature over time. Advantageously, the display **200** allows a caregiver to view multiple parameter histories side-by side in a visually-rich format. In this

manner, a caregiver can readily identify a patient having a serious medical condition or one incapable of adapting to a constantly changing medical environment. In particular, multiple-colored historical pie charts **210** are advantageously utilized to represent multiple parameters over time. Each colored pie chart **210** corresponds to a parameter and is a visual representation of the percentage of time spent in predetermined parameter ranges. Each range is assigned to a different color so that a serious medical condition can be rapidly discerned by simply comparing the multiplicity of the colors across the pie charts **210**. Specifically, pie charts **210** that have a rainbow of colors indicate physiological variability, which is a normal condition depending on the parameter. Pie charts **210** having only a single color, or just a few colors, indicate a patient that may not be adapting to their environment, which may indicate an abnormal condition depending on the parameter.

As shown in FIG. **2**, the display **200** has multiple-colored pie charts **210** representing parameters over time. In this embodiment, a SpO_2 pie chart **201**, a pulse rate (PR) pie chart **202**, a blood pressure (BP) pie chart **203**, a perfusion index (PI) pie chart **204**, a respiration rate (RR) pie chart **205** and a temperature (T) pie chart **206** are shown. The PR pie chart **202** has a rainbow of colors showing that the patient's pulse rate is constantly varying over time and indicating the patient is adapting to a varying environment in this respect. The T pie chart **206** has only a single color showing the patient's temperature is constant. The pie charts SpO_2 **201**, BP **203**, PI **204** and RR **205** each has moderate color changes in between a rainbow style and a single color showing the measured parameters SpO_2, BP, PI and RR are varying somewhat, but are not constantly varying over the monitored time duration. By viewing the color variety in pie charts **201-206**, the patient's condition may be determined as moderately good. Advantageously, the display of multiple parameters over time as colored pie charts may allow a ready determination of a patient's condition based upon color variability. If all or most of the pie charts **210** have a single color, the patient may have a serious condition in need of immediate medical attention.

FIGS. **3-4** illustrate a single-patient, single-parameter physiological status monitor **300**, **301** displaying a parameter over time, where the pie chart colors correspond to assigned ranges for the parameter. The displays **300**, **301** track a single parameter **320** for a single patient over a period of time and includes a pie chart **310**, a parameter indicator **320** and time duration **330**. The pie chart **310** has different zones **312**, **314**, **316** representing ranges of parameter values **340**. Each zone **312**, **314**, **316** is assigned a different color so as to be easily viewed by a user. The parameter indicator **320** indicates the particular parameter depicted in the charts, such as SpO_2, HbCO, HbMet, Hbt, Hct, PI or PVI, to name a few.

As shown in FIG. **3**, the single-patient, single parameter monitor **300**, **301** has parameter value ranges **340** (FIG. **3**) and the associated percentage of time **350** (FIG. **3**) the parameter **320** spends in each range **340**. Each of the ranges **340** is assigned a corresponding color in the pie chart **310**. In this manner, the details of each zone (color) can be viewed. For example, a green zone **312** indicates a normal condition, i.e. SpO_2 in the range of 85-100%, an orange zone **314** indicates an abnormal condition, i.e. SpO_2 in the range of 84-80%, and a red zone **316** indicates a serious condition, i.e. SpO_2 below 79%.

As shown in FIG. **4**, an alternative display **301** shows sequential time intervals **360** in the two unsafe zones **314**, **316** of the pie chart **310**. These unsafe intervals **360** are shown sequentially. When scrolled down, the display **360** shows all of the intervals in the two unsafe zones **314**, **316** until reaching the total duration of time. The intervals **360** have colors corresponding to the colors in the two unsafe zones **314**, **316** so as to provide the details of specific times spent in the unsafe zones. In another embodiment, the display **301** shows the longest intervals in the dangerous zone **316** of the pie chart **310**. By repeatedly clicking on the intervals, smaller intervals in the dangerous zone **316** are shown. In yet another embodiment, the display **301** shows intervals sequentially in all zones **312**, **314**, **316** of the pie chart **301**. The totality of intervals are shown by scrolling down the display **360** until the time duration **370** is displayed.

FIG. **5** illustrates a single-patient, multiple-parameter physiological monitor **500** displaying parameter alarm limits. The display **500** has a pie chart **510**, an indicator of duration of time **520**, a parameter value **540** and alarm limits **550**. The pie chart **510** has a zone **512** assigned in a distinct color, red, for example, representing a percentage of time in alarm during the duration of time. The alarm limits **550** are displayed next to the actual parameter value **540** having a lower limit **552** and an upper limit **554**. An alarm is activated when the limits **552**, **554** are exceeded.

Also shown in FIG. **5**, the display **500** has a graph **570** showing the parameter values versus time during the duration of time and thus the specific times in alarm are shown. By repeatedly clicking the graph **570**, the rest of the times can be shown until the end of the recorded time duration is reached. For example, FIG. **5** shows the lower limit **552** is **83** and no upper limit **554**. Because the graph **570** does not exceed the lower limit **83** between 8:00 to 9:00, no alarm is activated during this period of time. By clicking the graph **570**, other values and times in alarm will be shown until reaching the duration of 12 hours.

FIG. **6** illustrates a single-patient, single-parameter physiological status monitor **600** displaying parameter trends having integrated pie-chart summaries at specific time intervals. The display **600** has a trend line **610** with integrated pie-chart summaries **612** at specific time intervals. The display **600** also has a parameter indicator **620**, a duration of time **630** and a shift timeline **640**. The parameter indicator **620** corresponds to the trend line **610** and pie chart summaries **612**. The duration of time **630** is the duration of the trend line **610**. The trend line **610** has a plurality of pie charts **612** indicating a patient's parameter levels for each of the shifts over the shift duration. This trend line **610** advantageously provides an overview of each staff shift with respect to difficulty or success in patient management. In particular, the trend line **610** indicates acceptable levels of patient condition during each staff shift. This provides hospital or a medical institution feedback of medical care efficacy. For example, the monitor **600** advantageously provides information regarding which shift is maintaining the better patient management and which staff members are maintaining better patient management.

As shown in FIG. **6** as an example, six shifts and associated pie charts are displayed **600**. Shift 3 had difficulty with this patient. However, the patient improved over his three day stay across the different shifts.

FIG. **7** illustrates a single-patient, single-parameter physiological status monitor **700** has a pie chart **710**, a parameter indicator **720** and a duration of time indicator **730**. The pie-chart **710** has a height **705** that represents the total monitored time interval and pie slices **712**, **714**, **716** that each represent the percentage of time **750** a parameter is within the specified value range **740**. The pie chart **710** is a

histogram over a duration of time **730**, such as 24 hours. The pie chart **710** has different zones **712**, **714**, **716** indicating percentage of time **750** spent in each of the different value ranges **740**. Each zone **712**, **714**, **716** is assigned to a different color so as to be easily viewed by a user to determine, at a glance, an overview of a patient's condition over a time interval.

For example, in the pie chart **710**, a safe green color **712** indicates a normal condition occurring 75% of the time. An orange color **714** indicates an abnormal condition occurring 17% of the time. A red color **716** indicates a dangerous condition occurring 8% of the time. Accordingly, the details of the pie chart **710** are viewed in the range chart **740**, **750** showing 9% of time spent in a SpO_2 range of 100-97, 66% of time spent in a range of 96-94, 9% in a range of 93-95, 8% in a range 84-80 and 8% in a range of 79-0.

FIG. **8** illustrates a single-patient, single-parameter physiological status monitor **800** displaying iconic patterns utilized in lieu of colors, such as for a color blind user, a monochromatic display or a high contrast display. The display **800** has different shapes **810** representing percentages of time in each condition instead of a pie chart. Further, each shape **810** has lines, dots, circle patterns to distinguish each other rather than different colors assigned in a pie chart. Accordingly, value ranges **820** and percentages of time **830** have corresponding lines, dots, circle and square patterns, instead of different colors, assigned to each range.

A physiological status monitor has been disclosed in detail in connection with various embodiments. These embodiments are disclosed by way of examples only and are not to limit the scope of the claims that follow. One of ordinary skill in art will appreciate many variations and modifications.

What is claimed is:

1. A physiological status monitor responsive to an interconnected sensor, the sensor generates a sensor signal responsive to a physiological phenomenon and a display presents a measured physiological parameter responsive to the phenomenon, the physiological status monitor comprising:

a monitor configured to determine a physiological parameter in response to a sensor signal derived from a patient;

a single screen display incorporated with the monitor so as to display a summary screen corresponding to the physiological parameter;

a plurality of objects representing historical information regarding the physiological parameter for each of a plurality of patients;

the summary screen comprising the plurality of objects on the single screen display,

wherein each of the plurality of objects comprise a pie chart including:

a first zone representing a first combined amount of time the physiological parameter is within a first range of values over a monitored time period; and

a second zone representing a second combined amount of time the physiological parameter is within a second range of values different than the first range of values over the monitored time period, and

wherein a ratio of a first display portion associated with the first zone to a second display portion associated with the second zone in each of the plurality of objects is based at least in part on the first combined amount of time, the second combined amount of time, and the monitored time period;

the single screen display further configured to display a selected patient screen simultaneously with the summary screen, the selected patient screen including patient visualization of a selected patient from the plurality of patients,

the patient visualization comprising:

a first axis corresponding to a time scale, said time scale divided into a plurality of time periods;

a second axis correspond to a physiological parameter scale;

a first plot representing a trend of the physiological parameter of the selected patient as with respect to the first axis and the second axis;

a second plot representing an alarm limit corresponding to the physiological parameter;

for each of the plurality of time periods:

a time period pie chart representing a time summary of physiological parameter of the selected patient for the respective plurality of time periods, wherein the time period pie chart is integrated with the first plot and wherein the time period pie charts are connected by a line,

wherein the physiological parameter is oxygen saturation; and

the single screen display is further configured to display a multiple parameter screen for the selected patient, the multiple parameter screen comprising:

a perfusion index pie chart configured to display historical values of perfusion index of the selected patient over a plurality of perfusion index ranges, each of the plurality of perfusion index ranges including different colors; and

a pulse rate pie chart configured to display historical values of pulse rate of the selected patient over a plurality of pulse rate ranges, each of the plurality of pulse rate ranges including different colors.

2. The physiological status monitor according to claim **1**, wherein the first display portion comprises a first color and the second display portion comprises a second color different from the first color.

3. The physiological status monitor according to claim **1**, wherein the monitored time period comprises 12 hours.

* * * * *